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Does OFDI have a Carbon Emission Reduction Effect?

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Abstract

Based on the panel data of 30 provinces (municipalities and autonomous regions) in China from 2004 to 2017, this paper discusses the feasible path of carbon emission reduction from the perspective of OFDI under the background of dual carbon target, and innovatively applies the threshold panel model to investigate the mechanism of industrial structure in OFDI. The results show that OFDI has a significant impact on carbon emissions, and after a series of robustness tests, the results are still established; the influence of OFDI on carbon emissions has obvious regional heterogeneity and different degree of economic development; the proportion of the tertiary industry has threshold effect when the proportion of tertiary emissions is less than 73.2%, the increase of OFDI will lead to the increase of carbon emissions; when the proportion of the tertiary industry is higher than 73.2%, the improvement of OFDI will achieve the goal of carbon emission reduction. Based on this, China should further increase OFDI, promote the upgrading of regional industrial structure, and finally achieve the "double-carbon" target strategy.

Keywords

"Dual-carbon" Target; OFDI; Carbon Emission Reduction; Industrial Structure.

1. Introduction

With the signing of the Paris Agreement, the climate issue has become a major issue that all mankind have to face, and easing global warming has been put on the agenda of various countries. At present, China is in a critical period of the transformation of the principal social contradiction. The transformation of the economy to the green direction is the key to China's high-quality development, the enhancement of international competitiveness, and the stability of domestic economic growth. In order to achieve such a high goal, the Central Committee of the Communist Party of China clearly proposed in September 2020 to reach the "carbon peak" by 2030 and the "carbon neutral" by 2060. Under the background of "double-carbon" target strategy, China urgently needs to change the mode of economic growth by mainly relying on the quantitative expansion of production factors to relying on scientific and technological innovation to drive economic growth, so as to realize the transformation of green production mode. Therefore, the research of carbon emission mitigation path has become a key research field in China.

The impact of carbon emissions research has a long history as a subdivision of environmental research. As early as 1991, the Copeland[1]It has incorporated environmental policy into the research field of foreign trade, and concluded with the famous pollution shelter hypothesis. At present, the academic research mainly focuses on the endogenous factors affecting carbon emissions, and the main factors are the level of environmental regulation[2], technical competence[3]Spatial overflow[4], industrial structure[5], economics of scale[6], urbanization level[7]class. Considering that China, as a mainstay in promoting the development of the world economy, brings technology spillover effect and reverse technology spillover effect in the process of OFDI will directly lead to the change of China's industrial structure, and some scholars have said that industrial structure has a decisive impact on carbon emissions. Based

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on this, OFDI is likely to be an important factor affecting carbon emissions in China. Zhuang Dan yu[8]We also studied the environmental effect of China's OFDI on the host countries, and pointed out that an important factor of OFDI may lead to carbon emission reduction.

To sum up, the impact of carbon emissions is relatively diversified, among which the impact of OFDI on carbon emissions is a hot area that has been gradually concerned in recent years. At present, there are rich achievements on the relationship between OFDI affecting carbon emissions, but they mainly focus on studying carbon emission reduction in host countries, such as Nie Fei[9]Through the urbanization threshold model, he explored the impact of urbanization level on China and the carbon emissions of OFDI and host countries[10]In the context of environmental regulation level, the threshold effect of the impact of bidirectional FDI on the carbon emissions of the host country was explored. Liu Xia[11]Based on the perspective of industrial structure, OFDI will promote the carbon emissions of the host country. We found that the mechanism of OFDI to affect the carbon emissions of host countries has been fully studied at home and abroad, but the mechanism of carbon emission reduction of home countries has been rarely studied.

In this paper, OFDI and the carbon emission problem of the parent country are included in the same analysis framework, examining the carbon emission reduction effect of OFDI on the parent country, and examining the internal mechanism of both from the perspective of industrial structure. Different from the existing literature, the marginal contribution of this paper is: firstly, integrating the carbon emission from OFDI into the same analysis framework to enrich the research between OFDI and carbon emission from home country, which provides richer non-linear evidence for the internal mechanism between OFDI and carbon emission from the perspective of industrial structure, and provides empirical evidence for clarifying and formulating suitable policies.

2. Literature Review and Research Hypotheses

2.1. Literature Review

The research on the environmental impact of OFDI has a long history and each has its own characteristics. Unfortunately, there is not a consensus.Copeland[1]For the first time, a country's environmental policy was added to the research perspective of international trade, and the famous "pollution shelter" hypothesis was proposed, suggesting that OFDI would flow to countries with low environmental regulation and further aggravate the carbon emissions of the host countries. In contrast, the Reppelin-Hill[12]The "pollution halo hypothesis" proposed is believed that the technology spillover effect caused by foreign capital inflow will reduce the carbon emissions of the host countries due to the improvement of the pollution control level of the whole industry. Liu Feiyu[13]The study pointed out that the environmental impact of OFDI on the host countries is uncertain. There are relatively few studies on the impact of OFDI on the environment in the home country[14]It is concluded that the impact of OFDI on the environment has a strong regional difference. In the areas with a high level of economic development, the environment is affected by OFDI, thus showing a better phenomenon.

Compared with the environmental impact of OFDI, OFDI's promotion of carbon emission reduction is in its infancy, and different scholars have conducted research based on different paths and different perspectives. Liu Xia[11]The analysis based on industrial structure believes that OFDI suppresses carbon emission reduction, but its research in 2018 argues that the reverse technology spillover caused by OFDI promotes carbon emission reduction due to different perspectives[15]And the effect in the east. Yi Yanchun[4]From the perspective of spatial spillover effect, they explored the impact of OFDI on the carbon emissions of the parent country, and also believed that the carbon emissions were not reduced. Bai Zi letter[16]In this paper, the carbon reduction effect and realization mechanism of OFDI are studied, and the

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conclusion that the improvement of OFDI will reduce carbon emissions. Fei Neng cloud[17]In the study, he pointed out that OFDI has effectively reduced China's carbon emissions and improved the carbon productivity.permit[6]However, China's OFDI has intensified the domestic carbon emissions. Du Bin and Yu Guansheng, etc[18]The study believes that OFDI and carbon emissions can not be simulated using a linear function, and their relationship is closer to a quadratic function similar to the "n" type, that is, only when OFDI has a good impact on the environment when the economic investment is large. And Qu Xiaoe[19]It explored the intermediary effect of OFDI on carbon emissions by influencing industrial structure, green technology innovation, factor market distortion, and economic scale in other aspects. It can be seen that the academic community has studied carbon emissions according to the traditional environmental research path. Although it has just started, the mechanism of OFDI affecting carbon emissions has been explored from multiple perspectives.

To sum up, the existing literature about OFDI affect carbon emissions to the author, but there are the following deficiencies: one is the current study on OFDI although rich, but often unilaterally examined the OFDI on a factor, OFDI influence on multiple factors is still in its infancy, less research. Second, research on the mechanism of carbon emissions caused by OFDI is extremely scarce. Qu Xiaoe[19]Although it points out the mediation effect of different variables on carbon emissions, it does not take into account the possible carbon emission reduction effect caused by the industrial structure changes caused by OFDI. Based on this, this paper will test the mechanism of industrial structure in OFDI affecting carbon emissions through the threshold regression model, and study the mechanism of OFDI on carbon emissions by changing the technical structure. In the face of increasing environmental problems and increasingly urgent economic green transformation, the investigation of whether OFDI can promote carbon emission reduction should obviously get more attention, and this study helps to make up for this deficiency.

2.2. The Research Hypothesis

Based on the proposal of the double-cycle strategy and the carbon emission reduction strategy, the issues related to the relationship between OFDI and carbon emission have attracted wide attention from the academic community. Many scholars have explored the internal correlation and influence mechanism of the two through different research perspectives and research methods. The flow direction of OFDI is an important factor affecting the carbon emissions of relevant countries. When OFDI is applied to countries with weak environmental regulation level, it can often promote carbon emission reduction in the host country; when OFDI flows to countries with strong environmental regulation level, it cannot alleviate the carbon emission reduction of the home country due to policy restrictions, and may even lead to the stagnation of domestic industrial structure optimization and ultimately hinder carbon emission reduction[20]. Nie Fei[9]In the panel data study of 30 provinces and autonomous regions in China, it is found that the carbon emission effect of OFDI is restricted by the threshold value of urbanization rate, that is, there is an inverted U relationship between carbon emission and urbanization rate. The effect of promoting carbon emission reduction in areas with OFDI is more significant than that in areas with low urbanization stage. In terms of mechanism, in the midstream urbanization rate section, OFDI can realize carbon emission reduction through some excess capacity output and industrial chain upgrading, and the transmission mechanism of OFDI to promote carbon emission reduction is structure effect and scale effect; in the high urbanization rate section, pollution-intensive industry output and technology spillover will be realized through OFDI, and scale effect and technology effect are the main part of the transmission path of the carbon emission effect of OFDI. Further analysis of the threshold effect of urbanization agglomeration cost can be found that the scale effect, structural effect and technical effect of OFDI correspond to the decline of carbon emission level in the stage of highly

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urbanization population crowding cost, the cost of intensified competition and environmental governance cost.permit[6]Studies have found that the impact of OFDI on carbon emissions has a very obvious regional heterogeneity. For areas with higher R & D investment and population education, the increase in OFDI will significantly reduce carbon emissions, but the increase in OFDI in areas with inadequate energy mix and insufficient investment in environmental governance will increase carbon emissions. Qu Xiaoe[19]Other studies have found that OFDI often affects carbon emissions indirectly through other economic variables affecting the country. Green technology innovation, economic scale, factor market distortion, and industrial structure all play a role in intermediary variables, etc. In general, OFDI can indirectly reduce the carbon emissions of the home country. Hai-yun liu[21]It is found that OFDI will significantly promote the local carbon emission reduction through the mechanism of scale effect, and some distortion of the factor market will significantly promote the OFDI of high economic development level group, but the influence of OFDI of low economic development level group does not have the significant effect of carbon emission reduction; in different scholars, OFDI in China often suppresses carbon emission reduction in areas with poor economic development and reasonable industrial structure, but promotes carbon emission reduction in those areas with good economic development and reasonable industrial structure.

Therefore, this paper proposes the following hypotheses:

H1: OFDI shows an inverted U-shaped nonlinear relationship between domestic and domestic carbon emissions.

The study on the influence mechanism of OFDI on carbon emissions is subdivided into different fields, among which the most important area is that the impact of OFDI on industrial structure further affects carbon emissions. In recent years, China is faced with the difficult problem of transformation from high-speed economic development to high-quality development, and the adjustment of industrial structure is an important field of high-quality economic development. At the same time, due to the long-term as a "factory" of the world, our country's environmental pollution and social contradictions have become very serious, with the development of lingnan model "three to a fill" as a typical representative, by transfer labor rent and environment and the development of fishing has reached the point of have to change, a lot of labor-intensive industries and capital intensive industries constantly discharge huge carbon emissions, seriously hindered the implementation of the double carbon strategy in our country, a serious threat to the people's health and the hills and green of the motherland. OFDI can often reduce carbon emissions by transferring highly polluting industries. However, if it cannot effectively transfer highly polluting industries, it invests OFDI too much in tertiary industries such as finance, but cannot reduce domestic carbon emissions. Even OFDI investment in some high-polluting enterprises will also lead to the improvement of domestic OFDI[11]. Thus, the different effects of OFDI on the industrial structure will have different impacts on carbon emission reduction. At the specific industry level, China can use OFDI to promote the low-carbon upgrading of the global value chain through corresponding technologies. In subdivided fields, marginal industrial transfer effect and reverse technology spillover effect will help upgrade the global value chain of China's equipment manufacturing industry[22]. The development and increasing proportion of high-tech industries in the region will effectively promote carbon emission reduction, which puts forward higher requirements for the flow direction of OFDI.

Therefore, the paper proposes the following theoretical hypotheses:

H2: OFDI can achieve its carbon emission reduction target by adjusting its industrial structure.

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3. Model Setting and Data Description

3.1. Model Establishment

According to hypothesis 1, to investigate the relationship between OFDI and carbon emission reduction, the econometric model is established as follows:

$$\ln co2_{it} = \alpha + \beta_1 \ln ofdil_{it} + \beta_2 \ln ofdil_{it}^2 + \beta_3 X + \mu_i + v_t + \varepsilon_{it} \quad (1)$$

$\alpha \mu_{it} \varepsilon_{it} \ln co2_{it}$Among them, i represents the province, t represents each year, represents the constant term, a virtual variable reflecting individual effect and time fixed effect, is a random disturbance term, representing the natural logarithm of carbon dioxide emissions of each province in each year. $\ln ofdil_{it} \ln ofdil_{it}^2$ It is the natural logarithm of annual OFDI in each province, which is the square of annual OFDI in each province to verify the possible inverted U-shaped relationship. X represents control variables, including lnpgdp (per capita GDP), urban (urbanization rate), second (proportion of secondary industry), eg (environmental regulation level) and eng (energy consumption level). Some variables adopt the form of a natural logarithm to reduce the volatility of the variables.

According to hypothesis 2, due to the differences in per capita GDP, energy consumption level and environmental regulation level under different industrial structures, the impact degree of the carbon emission effect of OFDI will also be different. Therefore, there may be a "threshold effect" in the relationship between the carbon emission effect of the industrial structure on OFDI. When the industrial structure exceeds a certain threshold, the urban carbon emissions will also change under the influence of OFDI. Therefore, this paper adopts the threshold regression model, with the industrial structure as the threshold variable, and conducts the threshold effect test, and the threshold model is set up as follows.

$$\ln co2_{it} = \alpha + \beta_3 \ln ofdil_{it} I(Third_{it} \le \eta) + \beta_4 \ln ofdil_{it} I(Third_{it} \ge \eta) + \beta_5 X + \mu_{it} + \varepsilon_{it} \quad (2)$$

$Urban_{it}$Among them, the urbanization rate of the province I in the t period is the threshold variable; η is the threshold value to be estimated, and I is the expression function.

3.2. Selection of Indicators

3.2.1. Interpreted Variable: Carbon Emission (lncc)

The explained variable in this paper is the carbon emissions in the corresponding year in each region. The carbon emission data presented in this paper are obtained from the CEADs China Carbon Accounting Database. In this paper, the total carbon emissions of each province are selected and the natural logarithm is treated. At the same time, for the robustness of the results, the logarithm is divided by the number of GDP per capita (lnco 2 _ gdp).

3.2.2. Core Explanatory Variable: OFDI (lnofdil)

The relevant data of OFDI comes from the China OFDI Statistical Bulletin published by the Ministry of Commerce, in which there are two data of OFDI stock and flow in each province. In this paper, the logarithm () of OFDI traffic is selected as the alternative variable of OFDI scale. Meanwhile, for the robustness of the results, the log () of OFDI stock replaces the stock of foreign investment.lnofdillnofdic.

3.2.3. Control Variables

In addition to the core explanatory variables, the following variables were selected as control variables in this paper.

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Per capita GDP: Some literature believe that per capita GDP is an important factor inhibiting carbon emission reduction[23]. As an important indicator to measure economic development, GDP can very effectively reflect the level of local economic development and consumption capacity. Considering that there are huge differences in geographical area, administrative division, population and other factors, this paper adopts the natural logarithm (lnpgdp) of human settlements GDP to measure the economic development level of each province. The expected symbol is a positive one.

Urbanization rate: According to relevant literature, the development of urbanization rate is conducive to promoting carbon emission reduction[24]However, there are also literature that the relationship between carbon emissions and urbanization rate presents an inverted U-shaped relationship[7]. Urbanization rate is one of the important factors for regional economic growth and industrialization level. In the field of energy consumption, there has been a lot of research on the status and role of cities in carbon emission, urbanization process and carbon emission level. It is generally believed that the scale effect and structural effect brought by urbanization are important factors affecting carbon emissions. However, with the improvement of China's economic development level and the optimization of industrial structure, the carbon emissions in some developed regions have a downward trend. Based on this, the urbanization rate (urban) is selected as one of the control variables, and the expected symbol is unknown.

Proportion of secondary industry: industrial structure is an important factor affecting carbon emissions. Related studies show that if the industrial structure is not reasonable, especially if the proportion of highly polluting industries is too high, OFDI will significantly increase its carbon emissions.[11]But if the industrial structure is reasonable and highly polluting industries move out with OFDI, OFDI will instead reduce carbon emissions[4]. Considering that the highly polluting industries are often concentrated in the secondary industry, the paper will use the proportion of the secondary industry (second) to measure the proportion of the secondary industry, and the expected symbol is unknown.

Environmental regulation level: environmental regulation level is often an important factor affecting carbon emissions. From game theory and cost theory, we can know that as the level of environmental regulation rises, the cost of carbon emissions will also rise, and producers will be in the cost and benefit consideration and reduce the production scale of high pollution, and thus reduce carbon emissions. However, if the lower level of regional environmental regulation is required and production costs fall, producers will expand the scale of production, leading to a further increase in carbon emissions[25]. Therefore, this paper uses the ratio of environmental governance investment to unit GDP to measure the level of environmental regulation (eg), and the expected symbol is negative.

Energy consumption level: Regional energy consumption level undoubtedly has an important impact on carbon emissions. For carbon emissions, the level of energy consumption, as the demand for energy production, will have a significant impact and transmission effect on the carbon emissions, and the scale of energy production will significantly affect the carbon emissions. Therefore, this paper selects the electricity consumption per unit of GDP to measure the energy consumption level (eng), and the expected symbol is positive.

3.2.4. The Threshold Variable

Related studies show that the proportion of the tertiary industry will significantly affect the mechanism of action of OFDI on carbon emissions (Yi Yanchun, 2020). Based on this, this paper adopts the tertiary industry proportion (tertiary) as the threshold variable to set up the threshold model, in order to obtain the specific threshold value of the tertiary industry affecting OFDI on carbon emissions.

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3.2.5. Data Description

This paper ranged from 2005 to 2018. Considering the availability of data, 30 provinces, municipalities and autonomous regions except Tibet were selected as samples. The data in this paper has two sources: first, the per capita GDP, pollution control level, the proportion of the secondary industry, the proportion of the tertiary industry and the urbanization rate are from the National Statistical Yearbook over the years; second, the power consumption per unit of GDP comes from the Energy Statistical Yearbook in the past years. The specific variables and descriptive statistics are shown in Table 1, and we can see that the observed value of all variables is 420. For data integrity reasons, the Tibet Autonomous Region, which has serious data loss, was removed. The remaining data cover the full range from 2004 to 2017.

Table 1. Descriptive statistical analysis

variable	observed value	mean	standard deviation	least value	crest value
explained variable					
Carbon emissions (lnco 2)	420	5.315	0.785	2.803	6.644
explanatory variable					
Foreign direct investment (lnofdil)	420	9.898	2.352	0	14.690
GDP per capita (lnpgdp)	420	10.300	0.683	8.346	11.770
Urbanization rate (urban)	420	52.650	14.310	26.280	89.600
Percentage of secondary industry (second)	420	46.700	8.083	19.010	61.500
Environmental regulation level (eg)	420	0.163	0.139	0.007	0.992
Energy consumption level (eng)	420	0.119	0.0760	0.038	0.521

4. Empirical Analysis

4.1. Benchmark Regression

In this paper, OFDI first gives a preliminary estimate of the impression of carbon emissions, and the stepwise regression method is used to control the regional fixed effect and year fixed effect in the measurement model. Table Table 22 reports the results of the benchmark regression. First (1) as on the basis of controlling the regional fixed effect and time fixed effect, only add OFDI once lnofdil this variable, the results show that the coefficient of lnofdil is 0.025, and highly significant for positive, indicating that after controlling the unobservable factors such as time and region, with the expansion of OFDI scale, carbon emissions will rise. According to the measurement model (1), the primary lnofdil of OFDI was added in the regression to verify the inverted U-type relationship of OFDI on carbon emissions, the coefficient of lnofdil2 is-0.007 and showed a significant negative correlation, and the coefficient of lnfodil rises to 0.134 and showed a significant positive correlation, that is, the influence relationship between OFDI and carbon emissions showed an inverted U-type. First (3) column regression added all the control variables of OFDI a regression, the lnofdil is no significant positive correlation, but per capita GDP, urbanization rate, environmental regulation level and energy consumption level reflects a significant positive correlation, namely the control variables diluted the core explanatory variables OFDI, indirectly illustrates the OFDI will through control variables to affect carbon emissions. Column (4) added all the control variables to the regression, and the results found that the lnofdil coefficient is 0.082, and still positive significant, the lnofdil2 coefficient is-0.005, and still a significant negative correlation, the relationship between OFDI and carbon emissions still presents a significant inverted U type. The impact of the four control variables of per capita GDP, urbanization rate, environmental regulation level and energy consumption level on

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carbon emissions is still reflected in a significant positive impact, while the proportion of the secondary industry shows an insignificant negative correlation.

Benchmark regression results show that the relationship between OFDI and carbon emissions a inverted U type, with the OFDI scale effect, structure effect, reverse technology overflow and related effect makes the OFDI scale small and carbon emissions showed a positive correlation, and OFDI larger and carbon emissions present a negative correlation, both OFDI scale small will inhibit carbon reduction, and OFDI larger scale will promote carbon reduction, the hypothesis.H_1.

Table 2. Benchmark regression

	(1)	(2)	(3)	(4)
	lnco2	lnco2	lnco2	lnco2
lnofdil	0.025***	0.134***	0.006	0.082***
	(0.007)	(0.015)	(0.007)	(0.016)
lnofdil2		-0.007***		-0.005***
		(0.001)		(0.001)
lnpgdp			0.287***	0.214***
			(0.080)	(0.078)
urban			0.022***	0.020***
			(0.004)	(0.004)
second			-0.001	-0.001
			(0.002)	(0.002)
eg			0.195***	0.162***
			(0.061)	(0.059)
eng			0.755***	1.006***
			(0.275)	(0.270)
_cons	4.622***	4.227***	0.960	1.425**
	(0.054)	(0.071)	(0.636)	(0.620)
N	420	420	420	420
F	132.273	148.308	139.483	143.551
Area fixation effect	control	control	control	control
Time fixed effect	control	control	control	control
R2	0.831	0.856	0.877	0.886

Note: Standard error of robustness in brackets, *, * * and * * * are significant at the levels of 10%, 5% and 1%, respectively, the same below.lnofdil2 Is lnofdil * lnofdil, the same as below.

4.2. Robustness Test

In order to ensure the robustness of the empirical conclusion in this paper, this paper, two methods for robustness analysis are selected. One is to replace the explanatory variable OFDI, the OFDI stock lnofdic, and in order to control the stability of the data, the natural logarithm of the variables is treated. The second is to replace the carbon dioxide emission of the explained variable, and select the carbon emission per unit of GDP for replace. Table 3 then reports the regression results of the robustness test for replacing the core explanatory variables, and Table 4 then reports the regression results of replacing the explained variables.

Column (1) of Table 3 shows the substitution variable of OFDI lnofdic after controlling for the fixed effects of region and time fixed effect, and the coefficient of lnofdic is 0.025 and is highly significantly positive. According to the measurement model (1), OFDI substitution variable lnofdic with the secondary lnofdic2 to verify the stability of OFDI on carbon emissions U, the results show that the coefficient of lnofdic2 is-0.010 and showed a significant negative

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correlation, while lnfodic coefficient rose to 0.259 and showed a significant positive correlation, namely the relationship between OFDI and carbon emissions showed a U conclusion still exists. First (3) column regression added all the control variables of OFDI a regression, while lnofdic coefficient down to 0.050, but still presents a significant positive correlation, and GDP per capita, urbanization rate, environmental regulation level and energy consumption level still shows a significant positive correlation, this shows that in the robustness test, control variables will still diluted the core explanatory variables OFDI, OFDI will control the variables affect carbon emissions. Column (4) adds all the control variables to the regression, and the results found that the lnofdic coefficient was 0.212 and still positively significant, the lnofdic2 coefficient was-0.009, and still a significant negative correlation, and the relationship between OFDI and carbon emissions still showed a significant inverted U type. At this time, the influence of the four control variables of urbanization rate, environmental regulation level and energy consumption level on carbon emissions is still a significant positive impact, while the per capita GDP shows a significant insignificant positive correlation, which is significantly diluted, and the proportion of the secondary industry shows a nonsignificant negative correlation.

Table 3. Test of robustness of replacement of core explanatory variables

	(1)	(2)	(3)	(4)
	lnco2	lnco2	lnco2	lnco2
lnofdic	0.080***	0.259***	0.050***	0.212***
	(0.012)	(0.021)	(0.011)	(0.024)
lnofdic2		-0.010***		-0.009***
		(0.001)		(0.001)
lnpgdp			0.209***	0.083
			(0.080)	(0.076)
urban			0.023***	0.018***
			(0.004)	(0.003)
second			-0.002	-0.001
			(0.002)	(0.002)
eg			0.189***	0.155***
			(0.059)	(0.055)
eng			0.710***	1.163***
			(0.268)	(0.258)
_cons	4.119***	3.387***	1.306**	1.903***
	(0.100)	(0.115)	(0.624)	(0.589)
N	420	420	420	420
F	147.075	179.470	147.551	163.153
Area fixation effect	control	control	control	control
Time fixed effect	control	control	control	control
R2	0.846	0.878	0.883	0.898

Table 4 columns (1) ~ (2) tests the robustness by simultaneously replacing the explained variable carbon emission lnco 2 as unit carbon emission lnco 2 _ gdp and the core explanatory variable lnofdil as lnofdic. The results can be seen. Although the coefficient of lnofdic decreased to 0.035 and 0.218, it was still significantly positive, indicating that OFDI still has a significant impact on carbon emissions, but the impact degree has a certain change compared with the benchmark regression. Similarly, column (4) reports the replacement of only the explained variable lnco 2 as lnco 2 _ gdp, which is still consistent with the benchmark regression, and the relationship between OFDI and carbon emissions is still an inverted U type.

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Table 4. replaces the robustness test of the explained variables

	(1)	(2)	(3)	(4)
	lnco2_gdp	lnco2_gdp	lnco2_gdp	lnco2_gdp
lnofdic	0.035***	0.218***		
	(0.011)	(0.024)		
lnpgdp	-0.448***	-0.589***	-0.382***	-0.473***
	(0.081)	(0.076)	(0.080)	(0.077)
urban	0.029***	0.023***	0.028***	0.025***
	(0.004)	(0.003)	(0.004)	(0.003)
second	-0.005**	-0.004**	-0.004**	-0.004**
	(0.002)	(0.002)	(0.002)	(0.002)
eg	0.210***	0.171***	0.224***	0.183***
	(0.060)	(0.055)	(0.061)	(0.058)
eng	0.848***	1.359***	0.898***	1.211***
	(0.272)	(0.257)	(0.275)	(0.264)
lnofdic2		-0.010***		
		(0.001)		
lnofdil			-0.003	0.092***
			(0.007)	(0.015)
lnofdil2				-0.006***
				(0.001)
_cons	-5.477***	-4.803***	-5.785***	-5.205***
	(0.633)	(0.586)	(0.637)	(0.608)
N	420	420	420	420
F	202.378	231.641	197.082	211.948
Area fixation effect	control	control	control	control
Time fixed effect	control	control	control	control
R2	0.912	0.926	0.910	0.920

The results of the robustness test are basically consistent with the ones presented by the benchmark regression, that is, the relationship between OFDI and carbon emissions is an inverted U type, which indicates that the hypothesis is valid and robust.H_1.

4.3. Regional Heterogeneity Test

Relevant literature shows that the impact of OFDI on carbon emissions will be affected by specific investment industries. The flow of OFDI to some backward technologies with large pollution will have a large positive impact on the carbon emissions of home countries, but the investment in emerging green industries such as new energy vehicles can reduce the local carbon emissions. Due to various reasons, the eastern, central and western regions of China have significant regional heterogeneity in OFDI, industrial structure, urbanization rate, environmental regulation level and other aspects. To further explore the mechanism of OFDI on carbon emissions, this paper conducted regional heterogeneity studies and replaced the robustness test of the explained variables to ensure the stability of the heterogeneity test. Table 5 reports the results of the regional heterogeneity test.

Columns (1) to (3) in the table provide group regression of the eastern, central and western regions, and control for year effects and region effects, including all control variables. The results show that OFDI only in the eastern part of China has an observed relationship with carbon emissions: it will be suppressed when the economic scale is small, and it will promote

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carbon emission reduction only when the economic scale is large. There is no significant relationship in the west.

Table 5. Results of the regression to test for regional heterogeneity

	(1)	(2)	(3)	(4)	(5)	(6)
	lnco2	lnco2	lnco2	lnco2_gdp	lnco2_gdp	lnco2_gdp
lnofdil	0.189***	-0.031	0.028	0.183***	-0.023	0.033
	(0.032)	(0.025)	(0.025)	(0.034)	(0.026)	(0.023)
lnofdil2	-0.009***	0.001	-0.002	-0.009***	0.001	-0.002
	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
lnpgdp	0.427***	0.152	-0.227	-0.334***	-0.571***	-0.983***
	(0.118)	(0.143)	(0.169)	(0.123)	(0.145)	(0.154)
urban	0.017***	0.015***	-0.010	0.027***	0.013***	0.002
	(0.004)	(0.004)	(0.016)	(0.005)	(0.004)	(0.015)
second	-0.002	0.000	-0.002	0.000	-0.004	-0.005
	(0.004)	(0.002)	(0.004)	(0.004)	(0.002)	(0.004)
eg	0.033	-0.068	0.217**	0.076	-0.006	0.205**
	(0.128)	(0.082)	(0.091)	(0.133)	(0.084)	(0.083)
eng	1.783	3.439***	-0.013	3.109**	3.273***	0.092
	(1.326)	(0.737)	(0.354)	(1.381)	(0.748)	(0.322)
_cons	-1.318	2.691**	6.727***	-7.978***	-3.458***	1.003
	(0.961)	(1.250)	(1.220)	(1.001)	(1.269)	(1.111)
N	140	126	154	140	126	154
F	48.758	123.600	62.216	106.189	215.095	63.156
Area fixation effect	control	control	control	control	control	control
Time fixed effect	control	control	control	control	control	control
R2	0.899	0.962	0.910	0.951	0.978	0.911

4.4. Test of the Heterogeneity of the Economic Development Level

After the regional heterogeneity test, this paper wants to further explore the path and deep mechanism of the impact of OFDI on carbon emissions. Considering that the central and western regions just in the economic level shows the trend from high to low, this paper further the economic development heterogeneity, by the average per capita GDP 10.3, the OFDI and the influence of carbon emissions economic development heterogeneity test, and for the robustness of heterogeneity test results, the explained variable carbon emissions for robustness test. Table 6 reports the regression results of the heterogeneity test for economic development.

In Table 6, column (1) shows the regression test for areas with GDP greater than 10.3, the coefficient of lnofdil is 0.165 and significantly positive, the coefficient of lnofdil2 is-0.008 and significantly negative, and the effect of OFDI on carbon emissions shows an inverted U type. In column (2), for regions whose per capita GDP was less than 10.3, the coefficient of lnofdil was-0.022 and significant at the 1% level, and the coefficient of lnofdil2 was 0.002 and significant at the 5% level. In relatively underdeveloped areas, the relationship between OFDI and carbon emissions presents a positive U type, namely OFDI scale hours OFDI and carbon emissions present a negative correlation, OFDI larger present a negative correlation, this may be due to the local economy is relatively backward, in OFDI larger scale cannot effectively move out of high pollution industry, and due to the OFDI to high pollution reverse technology spillover effect but further increased the local carbon emissions. Column (3) ~ (4) tests the robustness of replacing the explained variables. The results show that although the coefficient is reduced,

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the overall conclusion is not shaken. In the relatively backward areas, OFDI and carbon emissions are positive U-shaped. In the more economically developed areas, OFDI and carbon emissions show an inverted U-shaped pattern.

Table 6. Regression results of the heterogeneity test in economic development

	(1)	(2)	(3)	(4)
	lnco2	lnco2	lnco2_gdp	lnco2_gdp
lnofdil	0.165***	-0.022*	0.122***	-0.022**
	(0.044)	(0.012)	(0.045)	(0.011)
lnofdil2	-0.008***	0.002**	-0.006***	0.002**
	(0.002)	(0.001)	(0.002)	(0.001)
lnpgdp	0.211**	0.085	-0.652***	-0.412***
	(0.092)	(0.082)	(0.094)	(0.080)
urban	0.022***	0.008	0.032***	0.010*
	(0.004)	(0.005)	(0.004)	(0.005)
second	-0.005*	-0.001	-0.007***	-0.006***
	(0.002)	(0.002)	(0.003)	(0.002)
eg	0.001	0.009	0.100	0.003
	(0.068)	(0.045)	(0.070)	(0.044)
eng	0.425	0.167	0.642	0.698***
	(0.428)	(0.274)	(0.440)	(0.267)
_cons	1.092	3.708***	-3.712***	-4.353***
	(0.798)	(0.705)	(0.820)	(0.687)
N	230	190	230	190
F	22.248	190.240	146.187	157.741
Area fixation effect	control	control	control	control
Time fixed effect	control	control	control	control
R2	0.711	0.964	0.942	0.957

5. Mechanism Analysis

H_1 After the benchmark regression and the robustness test, it can be determined that the hypothesis is basically true. However, due to the results of the heterogeneity test, we found that the conclusions have obvious heterogeneity. In order to further explore the influence mechanism of OFDI on carbon emissions and seek the possible inflection point of inverted U-shaped regression, this paper takes the proportion of the tertiary industry as the threshold variable, and the results of the threshold regression test are reported in Table 7. Column (1) of Table 6 adopts the single threshold regression. The regression results found that the threshold value is 73.2%. When the tertiary industry is higher than 73.2%, OFDI will promote carbon reduction, while when the tertiary industry accounts for less than 73.2%, OFDI will inhibit carbon reduction. The double-threshold regression model is used in Table 6 in column (2). The regression results found that the threshold limits are 60.4465% and 73.2%, respectively. When the proportion of the tertiary industry is lower than 60.4465%, OFDI is positively correlated with carbon emissions, while the weak tertiary industry is higher than 60.45%, and when the tertiary industry is higher than 73.2%, the coefficient is further reduced to-0.023 and shows a significant negative correlation. Column (3) of Table 7 uses a multi-threshold model for regression. The regression results show that when the proportion of the tertiary industry is higher than 73.2%, OFDI will significantly inhibit carbon emissions. When the proportion of the tertiary industry is lower than 73.2%, OFDI shows a significant positive correlation with carbon

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emissions, while when the proportion of the tertiary industry is lower than 46%, OFDI and carbon emissions will show a significant positive correlation. In general, when the tertiary industry is set as the threshold variable, the threshold is 73.2%, and when the proportion of the tertiary industry is higher than 73.2%, OFDI shows a significant negative correlation with carbon emissions, otherwise it generally shows a positive correlation.

Table 7. Results of the threshold regression mechanism test

lnco2					
Single threshold estimation		Double threshold estimation		Three threshold estimation	
lnofdil	0.012*	lnofdil	0.014**	lnofdil	0.016**
(third<73.2)	(0.007)	(third< 60.4465)	(0.007)	(third<46)	(0.007)
lnofdil	-0.013	Lnofdil	-0.004	lnofdil	0.010
(third>73.2)	(0.009)	(73.2>third>60.45)	(0.008)	(60.45>third>46)	(0.007)
		lnofdil	-0.023***	lnofdil	-0.011
		(third<73.2)	(0.009)	(73.2>third>60.45)	(0.008)
				lnofdil	-0.031***
				(third>73.2)	(0.009)
lnpgdp	0.521***	lnpgdp	0.560***	lnpgdp	0.569***
	(0.045)		(0.046)		(0.045)
urban	-0.003	urban	-0.008**	urban	-0.007**
	(0.003)		(0.003)		(0.003)
second	0.004***	second	0.002	second	-0.001
	(0.001)		(0.001)		(0.002)
eg	0.086	eg	0.106*	eg	0.094
	(0.062)		(0.061)		(0.061)
eng	0.803***	eng	0.781***	eng	0.808***
	(0.294)		(0.289)		(0.285)
_cons	-0.320	_cons	-0.394	_cons	-0.364
	(0.321)		(0.316)		(0.312)
N	420	N	420	N	420
F	298.317	F	272.382	F	249.289
Area fixation effect	control	Area fixation effect	control	Area fixation effect	control
Time fixed effect	control	Time fixed effect	control	Time fixed effect	control
R2	0.845	R2	0.851	R2	0.855

6. Conclusion and Suggestion

In this paper, we investigate the impact of OFDI on carbon emissions, and use the inter-provincial panel data from 2004 to 2017 for dynamic panel analysis. On this basis, the mechanism of industrial structure on OFDI is investigated using the threshold panel model. The main conclusions of this paper are as follows: OFDI has a significant impact on carbon emissions. At the national level, OFDI and carbon emissions show an inverted U-shaped relationship. However, by region, OFDI and carbon emissions in the eastern region show an inverted U-shaped relationship, while the central region and the western region show a positive U-shaped relationship with different levels.There is significant economic development heterogeneity in the impact of OFDI on carbon emissions. For economically developed areas with per capita GDP higher than 10.3, the impact of OFDI on carbon emissions shows an inverted U-shaped relationship, while in relatively backward areas with per capita GDP lower than 10.3, OFDI presents a positive U-shaped relationship with carbon emissions.The impact of OFDI on carbon

emissions is highly correlated with the industrial structure. The results of the threshold panel model show that the increase of OFDI will promote carbon emission reduction only when the proportion of tertiary industry reaches 73.2%, while when the proportion of tertiary industry is less than 73.2%, the increase of OFDI will inhibit carbon emission reduction. Overall, the impact of OFDI on carbon emissions shows an inverted U shape that first rises and then decreases.

To sum up, the following policy implications can be drawn: First, further expand the strength of OFDI, absorb and introduce green production technology, production technology and management experience from developed countries, to serve China's two-carbon strategy. Second, to further develop the happy technology industry, accelerate the transformation of the economic structure, optimize the economic structure, and promote the implementation of the two-carbon strategy. Third, expand the related fields of OFDI, through the joint research of first-class universities, major laboratories and related enterprises, so as to get more advanced and more adapted to China's situation. Through the acquisition of high and new technology, it can serve the demand of reducing carbon emissions in China, so as to achieve the transformation of green economy, and regularly complete the two-carbon strategy.

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